United States Department of Energy
National Petroleum Technology Office

# List of NPTO Publications

Computer Software, Supporting Documentation, Reports, and more!

*Your source for information on DOE-funded Research and Development Projects.*

Find us on the web at http://www.npto.doe.gov

This is a guide to information on research and development efforts funded by the Department of Energy.

***TO ORDER, GIVE THE FULL TITLE OF THE REPORT, PUB ID #, AND ORDER #.***

NPTO will provide one copy of any individual report as long as our limited supply lasts. Please help us in our efforts to eliminate wasteful spending on government publications by requesting only those publications needed. Make your selection by PUB ID and ORDER # listed at the beginning of each citation, then fax or e-mail your request to:

National Petroleum Technology Office
Attn: Herbert A. Tiedemann
One West Third Street, Suite 1400
Williams Center Tower One, Tulsa, OK 74103
Phone: (918) 699-2017
Fax: (918) 699-2005
E-mail: htiedema@npto.doe.gov

This information is also available at
**http://www.npto.doe.gov**

## CONTENTS



## CATEGORY: CROSSCUTTING

**PUB ID** DOE/BC/14847-3 **ORDER #** 752072

**TITLE** *National Geoscience Data Repository System, Phase III: Implementation and Operation of the Repository,* Final Report, September, 1999, 31 pp.

**PUB DATE** 3/13/2000

**CONTRACTOR** American Geological Institute

The American Geological Institute's (AGI) National Geoscience Data Repository System (NGDRS) was initiated in response to the potential irrevocable loss or destruction of billions of dollars worth of domestic geoscience data as a consequence of the ongoing downsizing of the U.S. energy and minerals industry. Preservation and access to domestic geological and geophysical data are critical to the energy security and economic prosperity of our nation. There is a narrow window of opportunity to act before valuable data are destroyed. The data truly represent a national treasure and immediate steps must be taken to assure their preservation.

## CATEGORY: DIAGNOSTIC AND IMAGING SYSTEMS

**PUB ID** DOE/BC/14850-5 **ORDER #** 750251

**TITLE** *Fractured Petroleum Reservoirs,* Final Report, June 11, 1999, 268 pp.

**PUB DATE** 1/18/2000

**CONTRACTOR** Reservoir Engineering Research Institute

In this report the results of experiments of water injection in fractured porous media comprising a number of water-wet matrix blocks are reported for the first time. The blocks experience an advancing fracture-water level (FWL). Immersion-type experiments are performed for comparison; the dominant recovery mechanism changed from co-current to counter-current imbibition when the boundary conditions changed from advancing FWL to immersion-type. Single block experiments of co-current and counter-current imbibition determined that and co-current imbibition leads to more efficient recovery was found.

**PUB ID** DOE/BC/14869-8 **ORDER #** 750148

**TITLE** *Gypsy Field Project in Reservoir Characterization,* Final Report, June 1997-September 1998, 351 pp.

**PUB DATE** 2/01/2000

**CONTRACTOR** University of Oklahoma

The overall objective of this project was to use extensive Gypsy Field Laboratory and data as a focus for developing and testing reservoir characterization methods that are targeted at improved recovery of conventional oil. This report, describing progress since project report DOE/BC/14970-7, covers the period June 1997-September 1998 and represents one year of funding originally allocated for the year 1996. During the course of the work previously performed, high-resolution geophysical and outcrop data revealed the importance of fractures at the Gypsy site. In addition, personnel changes and alternative funding (OCAST and oil company support of various kinds) allowed us to leverage DOE contributions and focus more on geophysical characterization.

**PUB ID** DOE/BC/14894-16 **ORDER #** 750056

**TITLE** *Application of Artificial Intelligence to Reservoir Characterization: An Interdisciplinary Approach,* Final Report, October 1, 1993-August 31, 1997, 204 pp.

**PUB DATE** 1/07/2000

**CONTRACTOR** University of Tulsa

The primary goal of this project is to develop a user-friendly computer program to integrate geological and engineering information using Artificial Intelligence (AI) methodology. The project is restricted to fluvially dominated deltaic environments. The static information used in constructing the reservoir description includes well core and log data. Using the well core and the log data, the program identifies the marker beds and the type of sand facies, and in turn, develops correlations between wells. Using the correlations and sand facies, the program is able to generate multiple realizations of sand facies and petrophysical properties at interwell locations using geostatistical techniques. The generated petrophysical properties are used as input in the next step where the production data are honored. By adjusting the petrophysical properties, the match between the simulated and the observed production rates is obtained.

**PUB ID** DOE/BC/14966-10 **ORDER #** 756823

**TITLE** *Proof of Feasibility of the Through Casing Resistivity Technology,* Final Report, April 1988-March 1994, 300 pp.

**PUB DATE** 6/21/2000

**CONTRACTOR** ParaMagnetic Logging, Inc.

This project is to definitely prove that the resistivity of geological formations can be measured from within cased wells and to license the relevant patents and technology to major wireline service companies.

**PUB ID** DOE/BC/15170-1 **ORDER #** 751432

**TITLE** *Board on Earth Sciences and Resources and its Activities,* Annual Report, October 1, 1998-September 30, 1999, 13 pp.

**PUB DATE** 2/23/00

**CONTRACTOR** National Research Council

This 1999 annual report of the activities of the National Research Council's (NRC) Board on Earth Sciences and Resources (BESR) begins with an introduction to the Board. This report (1) lists activities of the Board sustained by Department of Energy support, (2) presents accomplishments of the Board, (3) describes current and proposed studies of the Board, and (4) provides a brief review of the Board's future plans.

**PUB ID** DOE/BC/15177-1 **ORDER #** 750060

**TITLE** *Fractured Petroleum Reservoirs,* Semi-Annual Report, October 14, 1999, 98 pp.

**PUB DATE** 1/10/2000

**CONTRACTOR** Reservoir Engineering Research Institute

Total compressibility in a fractured reservoir is estimated using the pressure response related to gravitational potential variations. Both the moon and the sun gravitational potentials are accounted for using the full expression by inclusion of longer-period components. The semi-diurnal and diurnal pressure data show substantial long-term variations. The gravitational potential also contains the same variation trend; the ratio between the potential and pressure has a fairly uniform value over successive cycles. The computed total compressibility is also fairly constant and independent of the cycle. Results show the effects of the time interval over which the pressure measurements are performed as well as the location.

## CATEGORY: DRILLING, COMPLETION, AND STIMULATION

**PUB ID** DOE/BC/14862-24 **ORDER #** 751965

**TITLE** *Productivity and Injectivity of Horizontal Wells,* Final Report, March 10, 1993-May 30, 1998, 45 pp.

**PUB DATE** 3/06/2000

**CONTRACTOR** Stanford University

One of the key issues addressed was pressure drop in long horizontal wells and its influence on well performance. Very little information is available in the literature on flow in pipes with influx through pipe walls. Virtually all of this work has been in small diameter pipes and with single-phase flow. In order to address this problem new experimental data on flow in horizontal and near horizontal wells have been obtained. Experiments were conducted at an industrial facility on a typical 6 1/8 ID, 100 feet long horizontal well model. Our new data along with available information in the literature have been used to develop new correlations and mechanistic models. Thus it is now possible to predict, within reasonable accuracy, the effect of influx through the well on pressure drop in the well.

## CATEGORY: ENVIRONMENTAL, SAFETY AND HEALTH

**PUB ID** DOE/BC/15030-1 **ORDER #** 756545

**TITLE** *Characterization of Bedded Salt for Storage Caverns—A Case Study from the Midland Basin, Texas,* Final Report, 2000, 115 pp.

**PUB DATE** 3/06/2000

**CONTRACTOR** Bureau of Economic Geology/ University of Texas @ Austin

The geometry of Permian bedding salt in the Midland Basin is a product of interaction between depositional facies and postdepositional modification by salt dissolution. Mapping high-frequency cycle patterns in cross section and map view using wireline logs documents the salt geometry. Geologically based interpretation of depositional and dissolution processes provides a powerful tool for mapping the geometry of salt to assess the suitability of sites for development of solution-mined storage caverns. In addition, this process-based description of salt geometry complements existing data about the evolution of one of the best-known sedimentary basins in the world, and can serve as a genetic model to assist in interpreting other salts.

**PUB ID** DOE/MT/95008-4 **ORDER #** 754302

**TITLE** *Developing a Cost-Effective Environmental Solution for Produced Water and Creating a "New" Water Resource,* Final Report, March 17, 1998, 300 pp.

**PUB DATE** 5/01/2000

**CONTRACTOR** ARCO Western Energy

The project goal is to convert a currently usable by-product of oil production, produced water, into a valuable drinking water resource. The project was located at the Placate Oil Field in Santa Clarita, California, approximately 25 miles north of Los Angeles. The project included a literature review of treatment technologies; preliminary bench-scale studies to refine a planning level cost estimate; and a 10-100 gpm pilot study to develop the conceptual design and cost estimate for a 44,000 bpd treatment facility. A reverse osmosis system was constructed, pilot tested, and the data used to develop a conceptual design and operational of four operational scenarios, two industrial water levels and two irrigation/potable water.

**PUB ID** DOE/SW/43123-1 **ORDER #** 750149

**TITLE** *Petroleum Technology Advances Through Applied Research by Independent Oil Producers,* Final Report, November 1999, 130 pp.

**PUB DATE** 1/18/2000

**CONTRACTOR** The Brashear Group LLC

Petroleum Technology Advances Through Applied Research by Independent Oil Producers is a program of the National Oil Research Program, U.S. Department of Energy. Between 1995 and 1998, the program competitively selected and cost shared twenty-two projects with small producers. The purpose was to involve small independent producers in testing technologies of interest to them that would advance (directly or indirectly) one or more of four national program objectives: 1) Extend the productive life of reservoirs; 2) Increase production and/or reserves; 3) Improve environmental performance; and 4) Broaden the exchange of technology information.

## CATEGORY: FIELD DEMONSTRATION

**PUB ID** DOE/BC/14936-15 **ORDER #** 755452

**TITLE** *Application of Advanced Reservoir Characterization, Simulation, and Production Optimization Strategies to Maximize Recovery in Slope and Basin Clastic Reservoirs, West Texas (Delaware Basin), Class III,* Annual Report, March 31, 1999-March 30, 2000 63 pp.

**PUB DATE** 5/24/2000

**CONTRACTOR** Bureau of Economic Geology

The objective of this Class III project was to demonstrate that detailed reservoir characterization of slope and basin clastic reservoirs in sandstones of the Delaware Mountain Group in the Delaware Basin of West Texas and New Mexico is a cost effective way to recover a higher percentage of the original-oil-in-place through strategic placement of infill wells and geologically based field development. Phase 1 of the project, reservoir characterization, was completed this year, and Phase 2 began. The project is focused on East Ford field, a representative Delaware Mountain Group field that produces from the upper Bell Canyon Formation (Ramsey sandstone). The field, discovered in 1960, is operated by Oral Petco, Inc., as the East Ford unit. A $CO_2$ flood is being conducted in the unit, and this flood is the Phase 2 demonstration for the project.

---

**PUB ID** DOE/BC/14937-11 **ORDER #** 753924

**TITLE** *Reactivation of an Idle Lease to Increase Heavy Oil Recovery through Application of Conventional Steam Drive Technology in a Low-Dip Slope & Reservoir in the Midway-Sunset Field, San Jaoquin Basin, California, Class III,* Annual Report, June 13, 1998-June 12, 1999, 43 pp.

**PUB DATE** 4/20/2000

**CONTRACTOR** University of Utah

During the initial phase of the project a multifaceted feasibility study was carried out to examine whether the pilot project could be justified technically and economically at this site. This study included: (1) Recompletion of 9 shut-in wells and drilling of an additional producer and a new temperature observation well. A core was taken from the reservoir interval in the new producer, Pru-101. The wells were produced by conventional cyclic steaming over a period of 15 months to establish a production baseline for the site, (2) characterization of the stratigraphy and petrophysical properties of the Monarch Sand reservoir using existing well logs and analyses on samples in the core taken from Pru-101. The resulting data were used to develop a geostatistical model of the reservoir at the Pru Fee property and a specific reservoir simulator for the pilot test site on the property, and (3) use of the reservoir simulator to test various steamflood and cyclic steaming production options leading to design of a production strategy for the pilot steamflood based on a four-pattern, 9-spot array covering 8 ac near the center of the 40 ac Pru Fee property. The array chosen required drilling additional producers and injectors to supplement the existing wells recompleted in the initial phase of the project.

---

**PUB ID** DOE/BC/14942-9 **ORDER #** 753525

**TITLE** *Advanced Reservoir Characterization and Evaluation of $CO_2$ Gravity Drainage in the Naturally Fractured Spraberry Trend Area, Class III,* Annual Report, September 1, 1998-August 31, 1999, 83 pp.

**PUB DATE** 4/11/2000

**CONTRACTOR** Pioneer Natural Resources

The overall goal of this project was to assess the economic feasibility of $CO_2$ flooding the naturally fractured Spraberry Trend Area in West Texas. This objective was accomplished by conducting research in four areas: 1) extensive characterization of the reservoirs, 2) experimental studies of crude oil/brine/rock (COBR) interaction in the reservoirs, 3) analytical and numerical simulation of Spraberry reservoirs, and, 4) experimental investigations on $CO_2$ gravity drainage in Spraberry whole cores. This report provides results of the fourth year of the five-year project for each of the four areas including a status report of field activities leading up to injection of $CO_2$ .

---

**PUB ID** DOE/BC/14953-26 **ORDER #** 750285

**TITLE** *Increased Oil Production and Reserves from Improved Completion Techniques in the Bluebell Field, Uinta Basin, Utah, Class I,* Final Report, September 30, 1999, 39 pp.

**PUB DATE** 1/19/2000

**CONTRACTOR** Utah Geological Survey

The objective of this project was to increase oil production and reserves by the use of improved reservoir characterization and completion techniques in the Uinta Basin Utah. To accomplish this objective, a two-year geologic and engineering characterization of the Bluebell field was conducted. The study evaluated surface and subsurface data, currently used completion techniques, and common production problems. It was determined that advanced case- and open-hole logs could be effective in determining productive beds and that staged-interval (about 500 ft [150 m] per stage) and bed-scale isolation completion techniques could result in improved well performance.

---

**PUB ID** DOE/BC/14957-27 **ORDER #** 756344

**TITLE** *Improved Oil Recovery in Fluvial Dominated Deltaic Reservoirs of Kansas - Near-Term, Class I,* Final Report, June 18, 1993-September 30, 1999, 156 pp.

**PUB DATE** 6/08/2000

**CONTRACTOR** University of Kansas Center for Research

This project involved two demonstration projects, one in a Morrow reservoir located in the southwestern part of the state and the second in the Cherokee Group in eastern Kansas. Morrow reservoirs of western Kansas are still actively being explored and constitute an important resource in Kansas. Cumulative oil production from the Morrow in Kansas is over 400,000,000 bbls. Much of the production from the Morrow is still in the primary stage and has not reached the mature declining state of that in the Cherokee. The Cherokee Group has produced about 1 billion bbls of oil since the first commercial production began over a century ago. It is a billion-barrel plus resource that is distributed over a large number of fields and small production units. Many of the reservoirs are operated close to the economic limit, although the small units and low production per well are offset by low costs associated with the shallow nature of the reservoirs (less than 1000 ft. deep).

**PUB ID** DOE/BC/14962-24 **ORDER #** 750872

**TITLE** *The Utilization of the Microflora Indigenous to and Present in Oil-Bearing Formations to Selectively Plug the More Porous Zones Thereby Increasing Oil Recovery During Waterflooding, Class I,* Final Report, November 1999, 95 pp.

**PUB DATE** 2/01/2000

**CONTRACTOR** Hughes Eastern Corporation

The objectives of this project were (1) to demonstrate the in situ microbial population in a fluvial dominated deltaic reservoir could be induced to proliferate to such an extent that they will selectively restrict flow in the more porous zones in the reservoir thereby forcing injection water to flow through previously unswept areas, thus improving the sweep efficiency of the waterflood and (2) to obtain scientific validation that microorganisms are indeed responsible for the increased oil recovery. One expected outcome of this new technology was the prolongation of economical life of the reservoir, i.e. economical oil recovery should continue for much longer periods in areas of the reservoir subjected to the MPPM technology than it would if it followed its historic trend.

**PUB ID** DOE/BC/14989-23 **ORDER #** 752175

**TITLE** *Application of Integrated Reservoir Management and Reservoir Characterization to Optimize Infill Drilling, Class II,* Final Report, March 2000, 29 pp.

**PUB DATE** 3/16/2000

**CONTRACTOR** TotalFina

The major purpose of this project was to demonstrate the use of cost-effective reservoir characterization and management tools that will be helpful to both independent and major operators for the optimal development of heterogeneous, low permeability carbonate reservoirs such as the North Robertson (Clearfork) Unit.

## CATEGORY: OIL FIELD PRODUCTION AND OPERATION

**PUB ID** DOE/BC/14994-20 **ORDER #** 750288

**TITLE** *Modification of Chemical and Physical Factors in Steamflood to Increase Heavy Oil Recovery,* Final Report, December 1999, 43 pp.

**PUB DATE** 1/19/2000

**CONTRACTOR** University of Southern California

This report covers the work performed in the various physicochemical factors for the improvement of oil recovery efficiency. In this context the following general areas were studied: (1) The understanding of vapor-liquid flows in porous media, including processes in steam injection; (2) the effect of reservoir heterogeneity in a variety of foams, from pore scale to macroscopic scale; (3) the flow properties of additives for improvement of recovery, efficiency, particularly foams and other non-Newtonian fluids; and (4) the development of optimization methods to maximize various measures of oil recovery.

**PUB ID** DOE/BC/14994-21 **ORDER #** 752174

**TITLE** *Research on Oil Recovery Mechanisms in Heavy Oil Reservoirs,* Final Report, August 26, 1996-August 25, 1999, 341 pp.

**PUB DATE** 3/13/2000

**CONTRACTOR** Stanford University

The research described here was directed toward improved understanding of thermal and heavy-oil production mechanisms and is categorized into: (i) flow and rock properties, (ii) in-situ combustion, (iii) additives to improve mobility control, (iv) reservoir definition, and (v) support services. The scope of activities extended over a three-year period. Significant work was accomplished in the area of flow properties of steam, water, and oil in consolidated and unconsolidated porous media, transport in fractured porous media, foam generation and flow in homogeneous and heterogeneous porous media, the effects of displacement pattern geometry and mobility ratio on oil recovery, and analytical representation of water influx.

**PUB ID** DOE/BC/15026-1 **ORDER #** 756282

**TITLE** *Analysis of Oil-Bearing Cretaceous Sandstone Hydrocarbon Reservoirs, Exclusive of the Dakota Sandstone, on the Jicarilla Apache Indian Reservation, New Mexico,* Topical Report, January 22, 1998-June 30, 1999, 60 pp.

**PUB DATE** 6/07/2000

**CONTRACTOR** U.S. Geological Survey

This is the Phase One contract report to the United States Department of Energy, United State Geological Survey and the Jicarilla Apache Indian Tribe on the project entitled "Outcrop Analysis of the Cretaceous Mesaverde Group: Jicarilla Apache Reservation, New Mexico." Field work for this project was conducted during July and August 1998, at which time fourteen measured sections were described and correlated on or adjacent to Jicarilla Apache Reservation lands. A fifteen section area, described east of the main field area, is included in this report, although its distant location precluded use in the correlations and cross-sections presented herein. Ground-based photo mosaics were shot for much of the exposed Mesaverde outcrop belt and were used to assist in correlation. Outcrop gamma-ray surveys at six of the fifteen measured sections using a GAD-6 scintillometer was conducted. The raw gamma-ray data included in this report will be analyzed as part of the ongoing Phase Two of this project.

**PUB ID** DOE/BC/15108-5 **ORDER #** 750877

**TITLE** *Novel $CO_2$-Thickeners for Improved Mobility Control,* Annual Report, October 1, 1998-September 30, 1999, 138 pp.

**PUB DATE** 2/01/2000

**CONTRACTOR** University of Pittsburgh

The objective of this study was to design, synthesize, and characterize thickening agents for dense carbon dioxide and to evaluate their solubility and viscosity-enhancing potential in $CO_2$. Hydrocarbon-fluorocarbon random copolymers, sulfated hydrocarbon-fluorocarbon random copolymers, semifluorinated trialkyltin fluorides and small hydrogen-bonding compounds were evaluated. Random copolymers of styrene and heptadecafluorodecyl acrylate were characterized by high solubility ion dense carbon dioxide and the most substantial increases in solution viscosity. Falling cylinder viscometry results indicated that the 29%styrene-71%fluoroacrylate bulk-polymerized copolymer induced 2-250 fold increases in viscosity at copolymer concentrations of 0.2-5.0wt%.

**PUB ID** DOE/BC/15110-3 **ORDER #** 753863

**TITLE** *Using Chemicals to Optimize Conformance Control in Fractured Reservoirs,* Semi-Annual Report, October 1, 1999-March 30, 2000, 15 pp.

**PUB DATE** 4/19/2000

**CONTRACTOR** New Mexico Petroleum Recovery Research Center

This research project has three objectives. The first objective is to develop a capability to predict and optimize the ability of gels to reduce permeability to water more than that to oil or gas. The second objective is to develop procedures for optimizing blocking-agent placement in wells where hydraulic fractures cause channeling. The third objective is to develop procedures to optimize blocking-agent placement in naturally fractured reservoirs. This research project consists of three tasks, each of which addresses one of the above objectives. Work is directed at both injection wells and production wells and at vertical, horizontal, and highly deviated wells.

**PUB ID** DOE/BC/15111-1 **ORDER #** 756541

**TITLE** *Responsive Copolymers for Enhanced Petroleum Recovery,* Annual Report, October 1, 1998-September 30, 1999, 142 pp.

**PUB DATE** 6/14/2000

**CONTRACTOR** University of Southern Mississippi

The objectives of this work were to: synthesize responsive, amphiphilic systems; characterize molecular structure and solution behavior; measure rheological properties of the aqueous fluids including behavior in fixed geometry flow profiles and beds; and to tailor final polymer compositions for in situ rheology control under simulated reservoir conditions. This report focuses on the first phase of our research emphasizing synthesis and the development of photophysical techniques and rheological means of following segmental organization at the structural level.

**PUB ID** DOE/BC/15209-1 **ORDER #** 751427

**TITLE** *Increased Oil Recovery from Mature Oil Fields Using Gelled Polymer Treatments,* Semi-Annual Report, June 7, 1999-December 7, 1999, 13 pp.

**PUB DATE** 2/23/2000

**CONTRACTOR** The University of Kansas, Center for Research Inc.

Gelled polymer treatments are applied to oil reservoirs to increase oil production to reduce water production by altering the fluid movement within the reservoir. This research program is aimed at reducing barriers to the widespread use of these treatments by developing methods to predict gel behavior during placement in matrix rock and fractures, determining the persistence of permeability reduction after gel placement, and by developing methods to design production well treatments to control water production. This report describes the progress of the research during the first six months of work. A Dawn EOS multi-angle laser light scattering detector was purchased, installed and calibrated. Experiments were conducted to determine the permeabilities of a bulk gel and of a filter cake which forms when a gel is dehydrated. The pressure at which a gel in a tube is ruptured was measured and was correlated to the length and diameter of the gel.

---

**PUB ID** DOE/BC/15211-3 **ORDER #** 750286

**TITLE** *A 2-D Pore-Network Model of the Drying of Single-Component Liquids in Porous Media,* Topical Report, December 1999, 37 pp.

**PUB DATE** 1/19/2000

**CONTRACTOR** University of Southern California

The drying of liquid-saturated porous media is typically approached using macroscopic continuum models involving phenomenological coefficients. Insight on these coefficients can be obtained by a more fundamental study at the pore- and pore-network levels. In this report, a model based on pore-network representation of porous media that accounts for various process at the pore-scale is presented. These include mass transfer by advection and diffusion in the gas phase, viscous flow in liquid and gas phases and capillary effects at the gas-liquid menisci in the pore throats.

---

**PUB ID** DOE/BC/15211-4 **ORDER #** 751982

**TITLE** *A Note on the Evaporation of a Stagnant Liquid,* Topical Report, February 2000, 23 pp.

**PUB DATE** 3/07/2000

**CONTRACTOR** University of Southern California

The main objective of this report was the understanding of the effect of higher pressures on the velocity of the gas-liquid interface. Experimental evidence suggests that high-pressure gas injection results under certain conditions in a decrease of the rate of the interface motion, a result that may be the result of gas dissolution and diffusion in the liquid phase. To explore this possibility, it was considered in this paper a simple 1-D model of this process. A liquid A, originally occupying a semi-infinite medium, is subject to evaporation and diffusion in a flowing gas B, the composition of which at the top of the medium (at z = 0) remains constant. Because of the possible high pressure in the gas, component B may solubilize and counter-diffuse in the liquid phase.

---

**PUB ID** DOE/BC/15211-6 **ORDER #** 756596

**TITLE** *The Dynamics of Combustion Fronts in Porous Media,* Topical Report, June 2000, 31 pp.

**PUB DATE** 6/15/2000

**CONTRACTOR** University of Southern California

In this report, a method for solving this problem by treating the reaction region as a place of discontinuities in the appropriate variables, which include, for example, fluxes of heat and mass was proposed. Using a rigorous perturbation approach, similar to that used in the propagation of flames and smoldering combustion, appropriate jump conditions that relate the change in these variables across the front was derived. These conditions account for the kinetics of the reaction between the oxidant and the fuel, the changes in the morphology of the pore space and the heat and mass transfer in the reaction zone. The modeling of the problem reduces to the modeling of the dynamics of a combustion front, on the regions of either side of which transport of momentum (fluids), heat and mass, but not chemical reactions, must be considered. Properties of the two regions are coupled using the derived jump conditions. This methodology allows to explicitly incorporate permeability heterogeneity effects in the process description, without the undue complexity of the coupled chemical reactions.

# Computer Software
## & Supporting Documentation

Personal Computer Programs are available on 3.5" HD 1.4 MB disks. The software can also be downloaded from the NPTO website at **www.npto.doe.gov/software/softindx.html**

1. DOE/BC-88/1/SP. *EOR Predictive Models: Handbook for Personal Computer Versions of Enhanced Oil Recovery Predictive Models.* BPO Staff. February 1988. 76 pp. NTIS Order No. DE89001204. FORTRAN source code and executable programs for five EOR Predictive Models shown below are available. The five recovery processes modeled are Steamflood, In-Situ Combustion, Polymer, Chemical, and $CO_2$ Miscible Flooding. The models are available individually. Min Req.: IBM PC/XT, PS-2, or compatible computer with 640 Kbytes of memory.

a. DOE/BC-86/6/SP. *Steamflood Predictive Model*, Supporting Technology for Enhanced Oil Recovery. Dec 1986, 594 pp. NTIS Order No. DE87001219.

b. DOE/BC-86/7/SP. *In-Situ Combustion Predictive Model*, Supporting Technology for Enhanced Oil Recovery. Dec 1986, 263 pp. NTIS Order No. DE86000264.

c. DOE/BC-86/10/SP. P*olymer Predictive Model*, Supporting Technology for Enhanced Oil Recovery. Dec 1986, 394 pp. NTIS Order No. DE87001207.

d. DOE/BC-86/10/SP. *Polymer/Waterflood Predictive Model: Windows Version 1.1:* June 1995. This is an update to the Polymer Flood Predictive Model (PFPM) released in 1986. An addendum is available describing the updated economic cost and tax functions included in this release. This serves as a supplement to the original PFPM user's manual. This version runs out of the Microsoft Windows environment and supports post-processing graphics. Min Req.: 80386, 4 Mbytes extended memory, and Windows v3.1.

e. DOE/BC-86/11/SP. *Chemical Flood Predictive Model*, Supporting Technology for Enhanced Oil Recovery. Dec 1986, 360 pp. NTIS Order No. DE87001208.

f. DOE/BC-86/12/SP. *$CO_2$ Miscible Flood Predictive Model*, Supporting Technology for Enhanced Oil Recovery. Dec 1986, 469 pp. NTIS Order No. DE87001209.

g. DOE/BC-86/12/SP. *$CO_2$ Miscible Predictive Model: Windows Version 1.1:* 1995. This is an update to the $CO_2$ Miscible Flood Predictive Model ($CO_2$PM) released in 1986. This version runs out of the Microsoft Windows environment and supports post-processing graphics. Min Req.: 80386, 4 Mbytes extended memory, and Windows v3.1.

2. DOE/BC-95/2/SP. *Infill Drilling Predictive Model: User's Guide and Documentation Manual - Release 1.2.0*, Feb. 1995 for the PC. FORTRAN source code and executable program. Min Req.: 80386/80387, DOS v3.1, and 2 Mbytes extended memory.

a. DOE/BC-95/2/SP. *Infill Drilling Predictive Model: Windows Version 1.1:* June 1995. This is an update to the Infill Drilling Predictive Model (IDPM) released in 1995. This version runs out of the Microsoft Windows environment and supports post-processing graphics. Min Req.: 80386, 4 Mbytes extended memory, and Windows v3.1.

3. DOE/BC/14960-7. *$CO_2$ Prophet: Water and $CO_2$ Flood Prediction Software.* $CO_2$ Prophet, conceived by Texaco Exploration and Production Technology Department (EPTD), was partially developed as part of the DOE Class I cost-share program "Post Waterflood, $CO_2$ Flood in a Light Oil, Fluvial Dominated Deltaic Reservoir" under DOE Contract No. DE-FC22-93BC14960. Min Req.: 80386/80387 and 4 Mbytes extended memory and will run under the Microsoft Windows environment. DOE does not provide technical support for this application.

4. DOE/BC-89/3/SP. *Handbook for Personal Computer Version of BOAST II: A Three-Dimensional, Three-Phase Black Oil Applied Simulation Tool.* Bartlesville Project Office. January 1989. 82 pp. NTIS Order No. DE89000725. FORTRAN source code and executable program. Min. Req.: IBM PC/AT, PS-2, or compatible computer with 640 Kbytes of memory.

5. NIPER-542. *BOAST-VHS: FORTRAN source code and executable program.* User's Guide and Documentation Manual, National Institute for Petroleum and Energy Research (NIPER). January 1992. 92 pp. NTIS Order No. DE92001021. Min. Req.: IBM PC/AT, PS-2, or compatible computer with 640 Kbytes of memory. Math coprocessor optional.

6. DOE/BC/14831-18. *BOAST-3: FORTRAN Source code and executable program.* User's Guide and Documentation Manual. Bartlesville Project Office, September 21, 1996 (version 1.6). BOAST-3 is a modified version of BOAST-II containing postprocessors COLORGRID and B3PLOT2. The executable was compiled with the 32-bit Microsoft PowerStation FORTRAN and is 100% compatible with Windows. Min Req.: 386/486 PC environment.

7. BOAST98: *(Version 4.2.3)* FORTRAN 90 source code and executable program. Visual, dynamic, and interactive update of BOAST3. Rock region saturation corrected by WOC and GOC. Interacts with EdBOAST. Beta tested. User's Guide and Documentation Manual. National Petroleum Technology Office by TRW Petroleum Technologies, December 1998. Compiled with Lahey FORTRAN 90 and ISS/Interacter. Min. Req. Windows95, Windows NT, or Windows 3.1 with Win32s installed. Recommend 32 MB memory. Anticipate need of 40 to 100 MB disk space.

8. EdBOAST: *Version 1.3.3,* FORTRAN 90 source code and executable program. Dialog oriented reservoir data editor for input files directed to BOAST98 and BOAST3. Graphic plots and spreadsheet import/export features. Interacts with BOAST98. Beta tested. User's Guide. National Petroleum Technology Office by TRW Petroleum Technologies, December 1998. Compiled with Lahey FORTRAN 90 AND ISS/Interacter. Min. Req. Windows98, Windows NT, or Windows 3.1 with Win32s installed. Recommend 32 MB memory.

9. DOE/BC-91/2/SP. *MASTER: Miscible Applied Simulation Techniques for Energy Recovery - Version 2.0.* User's Guide and Technical Manual. Morgantown Energy Technology Center (METC). February 1991. 192 pp. NTIS Order No. DE91002222. FORTRAN source code and executable program. Min. Req.: See Users Guide.

10. NIPER-705. *PC-GEL: A Three-Dimensional, Three-Phase, Permeability Modification Simulator.* IIT Research Institute, National Institute for Petroleum and Energy Research (NIPER). October 1993. 190 pp. NTIS Order No. DE94000104. FORTRAN source code and executable program. Min. Req.: IBM PC/AT, PS-2, or compatible computer with 640 Kbytes of memory Math coprocessor optional

11. DOE/BC/20006-18. *TRACRL-Single-Well Chemical Tracer Test Simulator.* A deliverable as part of "The Single-Well Chemical Tracer Method for Measuring Residual Oil Saturation-Final Report." Bartlesville Energy Technology Center (BETC), predecessor to National Institute for Petroleum and Energy Research (NIPER). October 1980. 190 pp. FORTRAN source code and sample input datasets for both PC and Apple environments. Executable program for the PC.

12. DOE/PC/91008-0042. *NPC Public Database: (NPCPUBDB.GEO)* Database developed for the National Petroleum Council (NPC) for its 1984 assessment of the nationís enhanced oil recovery (EOR) potential. The technical data description is at the reservoir level. Included with the database are the Appendices from the "TORIS Data Preparation Guidelines" defining the data elements in the database. Available in ASCII or Spreadsheet format.

13. DOE/PC/91008-0151. *Crude Oil Analysis Database: COADB, v2.0,* 1995. Database contains information on 9,056 crude oil analyses performed at the National Institute for Petroleum and Energy Research (NIPER). A printed user's guide is available by request. The database is also available on disk. Min Reqs.: DOS v5.0, 80386 processor, 4 MB RAM, and 20 MB hard disk memory.

14. DOE/PC/91008-0227. *Risk Analysis and Decision Making Software:* Software package includes tools for Monte Carlo simulation, best fit for distributed functions, sample or rank correlation, investment risk analysis, and EOR method screening. Developed at the National Institute for Petroleum and Energy Research (NIPER) by BDM-Oklahoma, Inc. A printed user's guide is available by request. Min Req. Windows v3.11, 8 MB hard disk space, 8 MB RAM, VGA color monitor, and an 80486 processor.

15. DOE/PC/91008-0261. *FRAC-EXPLORE:* Analyzes the characteristics and patterns of subsurface lineaments, fractures, and other geological features for the purpose of identifying the locations of potential subsurface oil and gas reservoirs. Developed at the National Institute for Petroleum and Energy Research (NIPER) by BDM-Oklahoma, Inc. A printed user's guide is available by request. Min Req. Windows v3.1, 6 MB hard disk space, 4 MB RAM, VGA color monitor configured to at least 800x600 resolution, and an 80386 processor.

16. Microbial Transport Simulator: The microbial transport simulator (MTS) is a three-dimensional, three-phase, multiple-component numerical model that permits the study of the transport of microorganisms and nutrients in porous media. Microbial parameters incorporated into MTS include: microbial growth and decay, microbial deposition, chemotaxis, diffusion, convective dispersion, tumbling, and nutrient consumption. Governing equations for microbial and nutrient transport are coupled with continuity and flow equations under conditions appropriate for a black oil reservoir. The model's mathematical formulations and preparation procedures of data files for conducting simulations using MTS are described in the electronic manual. Min. Req.: IBM PC/AT, PS-2, or compatible computer with 640 Kbytes of memory. Math coprocessor optional.

17. DOE/PC/91008-0346. *User's Guide and Documentation Manual:* The improved PC-GEL permeability modification simulator is an improved version of National Institute for Petroleum and Energy Research's (NIPER's) PC-GEL permeability modification simulator. It is developed under a cooperative research and development agreement (CRADA) established between BDM-Oklahoma, Inc. and Schlumberger Dowell. In addition to the features included in the PC-GEL simulator, the improved version includes a radial model, a thermal energy equation in both rectangular and cylindrical coordinates, (r,0,z), a modified version of Schlumberger Dowell's wellbore simulator, a fully implicit time-stepping option, and the temperature-dependent gelation kinetics and fluid rheology of an inorganic delayed gel system (DGS). Detailed description of the development of these new features is reported in a topical report entitled, "Development of an Improved Permeability Modification Simulator."

18. DOE/PC/91008-0361. *Maganom Software USER'S GUIDE:* Maganom is a computer program for modeling magnetic data over 2-D structure. The program computes the magnetic anomalies across 2-D structure (models) to allow you to compare observed and computed magnetic data across the model structure. If a match between the computed and the observed magnetic values is unsatisfactory, you construct a new model and rerun Maganom to recalculate new magnetic values. In this way, you can continue calculations until you obtain a satisfactory match between the observed and the calculated values.

19. DOE/PC/91008-0349. *Gravanom Software USER'S GUIDE:* Gravanom is a computer program for modeling gravity data over 2-D structure. The program computes the gravity anomalies across 2-D structure (models) to allow you to compare observed and computed gravity data across the model structure. If a match between the computed and the observed gravity values is unsatisfactory, you construct a new model and rerun Gravanom to recalculate gravity values. In this way, you can continue calculations until you obtain a satisfactory match between the observed and the calculated values.

20. DOE/PC/91008-0344. *Development of an Improved Permeability Modification Simulator:* This report describes the development of a permeability modification simulator. The improved simulator is developed through the modification of the existing PC-GEL permeability modification simulator to include a radical, a thermal energy equation, a modified version of Schlumberger Dowell's wellbore simulator, and a fully implicit time-stepping option. The developed simulator describes the flow of the injected fluid in the wellbore, through the perforations, and the reservoir. Flow in the reservoir is three dimensional and includes thermal conduction/convection among the injected fluid, the reservoir formation, the reservoir fluids, the overburden, and the underburden.

21. Exploration and Production CD-ROM: A new CD-ROM available from the DOE's National Petroleum Technology Office (NPTO) contains more than 20 programs, database applications, and model documentation fields for the oil and gas industry. The CD also features BOAST '98–the newest version of the DOE's popular software.

# NPTO Order Form

To order from this list, fax or e-mail the information requested below to:

**Herbert A. Tiedemann**
**National Petroleum Technology Office**
**One West Third Street, Suite 1400**
**Williams Center Tower One**
**Tulsa, OK 74103**
**(918) 699-2005 Fax**
**E-mail: htiedema@npto.doe.gov**

Name _____

Organization _____

Address or P.O. Box _____

City, State, Zip _____

Date _____ Signature _____

Telephone _____ Fax _____

E-mail _____

Send the following publications, software, or documentation: (Please list report numbers/order numbers)

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

_____ _____

Please indicate below the type of company or organization that you represent:

- ❑ College/University
- ❑ Consultant
- ❑ Oilfield Supply
- ❑ Service Company
- ❑ Independent
- ❑ Major
- ❑ DOE
- ❑ Foreign Company
- ❑ Federal/State/Local Government
- ❑ Foreign Government
- ❑ Association or Society
- ❑ Other _____

Please indicate your focus area:

- ❑ Class Program
- ❑ Tech Develop with Independents
- ❑ Native American Initiatives
- ❑ Reservoir Management
- ❑ Other _____
- ❑ Imaging
- ❑ Drilling
- ❑ Environmental
- ❑ Processing
- ❑ Geoscience
- ❑ Data & Analysis
- ❑ Technology Transfer
- ❑ Heavy Oil
- ❑ General Research
- ❑ Supporting Research

National Petroleum Technology Office
Attn: Herbert A. Tiedemann
One West Third Street, Suite 1400
Williams Center Tower One
Tulsa, OK 74103





86 List of NPTO Publications
January–June 2000

DOE/BC-00/4/SP
August 2000